Penile Prosthesis Infections—A Review of Risk Factors, Prevention, and Treatment

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ABSTRACT

Introduction: Inflatable penile prosthesis (IPP) surgery has been performed for more than 40 years. IPP infection rates have decreased owing to advances in manufacturing and surgical technique but have remained a devastating complication.

Aims: To describe the pathophysiology of infections, examine evidence associating clinical risk factors with IPP infection, assess the benefit of techniques aimed at preventing and managing infection, and discuss future directions.

Methods: PubMed and Google Scholar were searched for studies relating to IPP infections.

Main Outcome Measures: A comprehensive review of the literature on IPP infections focusing on predisposing factors and ways to prevent and treat.

Results: There are two types of IPP infections: those caused by coagulase-negative *Staphylococcus* species, which present mildly, and those caused by organisms that are more virulent and systemically toxic. Biofilm on devices protects bacteria from immunologic responses and antibiotics. Much research has targeted biofilm. Spinal cord injury, IPP revision, and longer operative times predispose to IPP infection. Other factors, such as diabetes, immunosuppression, and concomitant surgeries, lack sufficient evidence to determine conclusively. Methods that decrease infections include using infused prostheses and adhering to surgical techniques that avoid prolonged wound exposure. Techniques that might prevent IPP infection but lack definitive evidence are using post-operative antibiotics past 24 hours, shaving with clippers, and prepping with chlorhexidine-alcohol. Different treatments for IPP infections exist. Antibiotics should be followed by explantation if no improvement occurs. Device replacement can be immediate or delayed depending on infection severity and other variables such as erosion. Various techniques are proposed to prevent corporal fibrosis after IPP removal.

Conclusion: We reviewed studies to determine true risk factors and the techniques that have true impact on infection prevention. Newer studies focusing on prevention and disruption of biofilm will be key in advancing the best outcomes.

Key Words: Penile Prosthesis; Infection; Prevention; Treatment; Biofilm

INTRODUCTION

Modern artificial penile prosthesis surgery began in the 1950s as splints implanted beneath Buck's fascia and progressed to intracavernosal rods in the 1960s.[1-3] In 1973, Brantley Scott et al[4] published a study on the first five patients who had undergone successful surgical implantation of an inflatable penile prosthesis (IPP). It is estimated that up to 25,000 IPPs are implanted each year in the United States.[5] Steady improvement has been made in the function and mechanical durability of these devices. These advances and a decrease in infection rates have led to a 10-year survival of implants of 88.6%.[6] However, the true overall rate of IPP infection might be underreported because of the voluntary nature of data collection, industry databases that do not track replacements of their device with a different brand, and nearly 30% of reoperations can occur at hospitals different from the initial surgery.[7,8]

This review critically analyzes the literature on penile prosthesis infection. We address possible controversies concerning this topic. We describe differences between acute and chronic infections and discuss the role that biofilm plays. We discuss the evidence associating clinical risk factors with prosthesis infection

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and assess the benefit of pre- and peri-surgical techniques used to prevent infection. The review concludes with an analysis of approaches for managing an infected prosthesis and a discussion on future directions for treating and preventing this complication.

TYPES OF INFECTIONS

A penile prosthesis infection can initially present with new-onset pain around the device, erythema, warmth, induration of the tissue over the prosthesis component, and sticking of the pump to the scrotal skin.[9] There are two major types of infection of penile prostheses. The local and less aggressive type usually consists of a benign presentation more than 6 weeks after surgery. Some additional signs can include a sinus tract with weeping of clear and odorless fluid or wound dehiscence.[10] These types of infections are usually attributed to *Staphylococcus epidermidis,* representing 35% to 80% of infections.[9,11] Despite its prevalence, infections with this organism and other coagulase-negative *Staphylococcus* species, such as *Staphylococcus lugdunensis,* usually are not systemically toxic, with affected patients usually not appearing ill, having a normal serum white blood cell count, and no fevers.[12] However, if not treated, the infection will result in device erosion and extrusion.[13]

The second and more aggressive type of infection is due to organisms that are known to cause systemic effects that are more toxic and account for approximately 25% of infections: *Enterococcus, Staphylococcus aureus, Klebsiella, Serratia, Escherichia coli,* and *Pseudomonas.* These organisms are more virulent and cause infections less than 2 months after the implant is placed. Patients are obviously sick, with swollen surgical sites and fevers, possibly with drainage of purulent fluid, and fluctuance around the device.[10,14,15] On rare occasion, other organisms might be cultured from an extracted device, such as *Neisseria gonorrhoeae* and fungi. The widespread use of coagulase-negative *Staphylococcus*-targeting antibiotic-coated implants has resulted in a transition from the dominance of coagulase-negative *Staphylococcus* species to the more virulent organisms.[10] Distinguishing the type of infection is vital, because treatment regimens will vary accordingly, as discussed later.

PATHOPHYSIOLOGY OF DEVICE INFECTIONS

Most prosthesis infections occur secondary to bacterial seeding before or during implantation.[10] Bacteria attach to the prosthesis by secretion of adhesion molecules. Once attached, the colonies of bacteria secrete components of the biofilm, which consists of polysaccharide, proteins, glycoproteins, glycolipids, and extracellular DNA.[16,17] The biofilm impedes antibiotic penetration, decreases immune cell phagocytosis, and traps nutrients, making treatment of prosthesis infection challenging.[18] Biofilm provides invading bacteria safe harbor from the immune system by causing a decrease in the activity of granulocytes and lymphocytes and inducing a state of decreased biological bacterial activity that lowers uptake of any surrounding antibiotics.[19,20] This decrease in biological activity allows for bacteria to survive even with antibiotic concentrations greater than 1,000 times what would otherwise be effective.[21] Furthermore, bacteria in the biofilm exchange genetic material that allows for the development and spread of antibiotic resistance.

Conservative medical management for infected prostheses, such as simple administration of antibiotics, seldom works because of the protection that biofilm affords bacteria. Cultures from the surface of an extracted implant will not necessarily show the problematic organism that is embedded within the biofilm, which can be a setback for choosing the right antibiotic.[20] After a device is removed, the biofilm can remain within the wound if a thorough washout is not performed.[22,23] In addition, 40% to 70% of implants removed for mechanical malfunction have a positive culture because of the presence of biofilm, even when there have been no prior signs or symptoms of infection.[24,25] As a result, when these patients undergo a repeat prosthesis placement, the rates of infection can be as high as 18.8%.[26]

INFECTION RISK FACTORS

Diabetes

It is unclear whether the presence of diabetes affects the rate of infection for penile prostheses because there are studies supporting and refuting this claim.[21] Despite inconclusive evidence, it has become dogma to categorize diabetes as a high risk for prosthesis infection.

In a classic prospective study of patients undergoing penile prosthesis surgery, Bishop et al[27] argued that diabetes was a risk factor. Of the 90 patients in their study, 5 developed infections that occurred in patients who had diabetes ($P < .009$). Of these five patients with infection and diabetes, four had glycated hemoglobin (HbA_{1c}) levels higher than 11.5% ($P < .0003$), which suggested that those with poorly controlled diabetes were at greater risk than patients with adequate control.[27] A different study analyzed a manufacturer's database of 40,000 virgin implants and found that patients with diabetes had a significantly higher rate of revisions owing to infection at 7 years (1.88%) than patients without diabetes (1.53%; $P = .0052$ by log-rank test).[28] However, the data were obtained from voluntary patient information forms (response rate = 85%).

Most studies have shown no significant association between diabetes and increased risk of penile prosthesis infection.[26,29,30] In a retrospective study of 152 patients with implants, Lotan et al[18] did not find a significant difference in device infection survival between patients with and those without diabetes. Wilson et al[31] also found no statistically significant increase in risk of infection in a prospective study of 389 IPPs when patients were compared by levels of HbA_{1c}, fasting glucose, or insulin dependence. In a different retrospective study of 1,337 consecutive IPP implantations, Wilson and Delk[32] found no difference in infection rates between patients with and those without diabetes undergoing a first-time surgery. However, of those